PHOTOELECTRIC CONVERTER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a photoelectric converter such as an imaging apparatus employing photoelectric conversion devices such as photodiodes.

Description of Related Art

An imaging apparatus has a number of pixels formed in an imaging area (a light receiving portion) thereof receive light signals from a subject, photoelectrically converts the light signals into signal charges, transfers the converted electric signals, thereby imaging the subject.

Fig. 7 shows a CCD imaging apparatus as an example of an imaging apparatus.

Light incident on a photodiode 1 is photoelectrically converted into a signal charge, the signal charge is read out to a vertical CCD portion 3 via a readout gate 12A, the signal charge is transferred by supplying transfer clocks of, e.g. $\phi V1$ to $\phi V4$ to the vertical CCD 3, and the signal charge is directed to an output portion in a horizontal CCD portion to which transfer clocks of, e.g. $\phi H1$ and $\phi H2$ are supplied, where

charge voltage conversion and the like are performed to produce an image signal.

By the way, recent imaging apparatuses, particularly a CCD (charge coupled device) imaging apparatus and the like, tend to have more compact unit cells and increase the amount of charges stored in a sensor to improve sensitivity.

For this reason, it is becoming difficult to read out charges into a vertical CCD, which is a charge transfer portion, from a photodiode comprising a light receiving portion (pixel portion) via a gate portion.

Particularly, as shown in Figs. 4A and 4B, in the case of an imaging apparatus in which the horizontal size of a unit cell comprising a photodiode portion 1 and a gate portion 2 is longer than the vertical size, it is more difficult to read out charges into a vertical CCD portion 3. Fig. 4A shows a schematic layout of the unit cell from which the vertical CCD portion is excluded, and Fig. 4B shows a schematic layout of the unit cell including the vertical CCD portion (hereinafter the same is also true of other drawings). L_{2-1} or W_1 in the drawings is the width of a readout gate 2A and L_{1-1} is the width of a gate 2B which is not related to readout. The reference numeral 4 designates a channel stopper for

separating unit cells.

To solve such a problem, the following two measures are taken. One is, as shown in Figs. 5A and 5B, to enlarge the readout gate width (gate length in a direction orthogonal to a carrier travel direction: the same is true of the following descriptions) $L_{2\text{-}2}$ or W_2 of a readout gate portion 2A (indicated by white background or oblique lines) of the gate portion 2. The other is, as shown in Fig. 6A and 6B, to reduce a readout gate length (gate length in a carrier travel direction: the same is true of the following descriptions) $1_{1\text{-}3}$.

However, in the layouts of Figs. 5A and 5B, a ratio between the two gates of the vertical CCD portion 3, that is, a gate 2A to read out charges and a gate 2B which is not related to readout, is different. Consequently, the charge capacity of the vertical CCD portion is liable to become small or charges are liable to be unsuccessfully transferred.

In the layouts of Figs. 6A and 6B, the gate 2 itself fails to play the role of a barrier during off operation, with the result that charges leak from the photodiode portion 1 to the vertical CCD portion 3 or light passes between a silicon film and a shielding film (both are not shown) below the gates, and photoelectric

conversion may occur within the vertical CCD portion 3.

SUMMARY OF THE INVENTION

The present invention has been made in view of the above situation, and its object is to provide a photoelectric converter such as an imaging apparatus which smoothly reads out charges without influencing the charge capacity and charge transfers of a charge transfer portion and can reduce power consumption by reducing a readout voltage.

Specifically, a photoelectric converter of the present invention comprises a light receiving portion, a gate portion, and a charge transfer portion, wherein the gate width of the gate portion is wider at the light receiving portion side than at the transfer portion side.

Thus making a gate width wider at a light receiving portion side than at a charge transfer portion side helps to enlarge an area of an electric field applied to the gate in an area to admit charges from the light receiving portion (accordingly, the electric field of the gate area can be intensified), with the result that charges can be easily read, and if a readout capacity is the same, a charge readout voltage can be reduced to reduce power consumption. Yet, since such an effect can be achieved

without changing a gate width at the charge transfer portion side, no influence is exerted on the charge capacity and charge transfers of the charge transfer portion and other characteristics also do not deteriorate.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A and 1B show main portions of an imaging apparatus in a first embodiment of the present invention; Fig. 1A is a layout diagram centered on a gate portion, and Fig. 1B is a layout diagram of a unit cell.

Figs. 2A and 2B show main portions of an imaging apparatus in another embodiment of the present invention; Fig. 2A is a layout diagram centered on a gate portion, and Fig. 2B is a layout diagram of a unit cell.

Figs. 3A and 3B show main portions of an imaging apparatus in yet another embodiment of the present invention; Fig. 3A is a layout diagram centered on a gate portion, and Fig. 3B is a layout diagram of a unit cell.

Figs. 4A and 4B show main portions of a conventional imaging apparatus; Fig. 4A is a layout diagram centered on a gate portion, and Fig. 4B is a layout diagram of a unit cell.

Figs. 5A and 5B show main portions of another conventional imaging apparatus; Fig. 5A is a layout

diagram centered on a gate portion, and Fig. 5B is a layout diagram of a unit cell.

Figs. 6A and 6B show main portions of yet another conventional imaging apparatus; Fig. 6A is a layout diagram centered on a gate portion, and Fig. 6B is a layout diagram of a unit cell.

Fig. 7 shows a CCD imaging apparatus as an example of an imaging apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is preferably constructed as an imaging apparatus in which the light receiving portion has pixels comprising photodiodes and the like, and the charge transfer portion comprises charge coupled devices.

As to the shape of the gate portion, although there are no special limitations thereon, preferably, the gate width is narrower from the light receiving portion toward the transfer portion straightly, curvedly, or gradually.

Furthermore, preferably, the gate portion comprises a first gate portion the gate width of which is narrower from the light receiving portion toward the transfer portion, and a second gate portion provided with an identical gate width from the first gate portion further toward the charge transfer portion.

Hereinafter, the present invention will be described more specifically based on an embodiment of the present invention applied to a CCD imaging apparatus.

Figs. 1A and 1B show main portions of a CCD imaging apparatus; Fig. 1A is a layout diagram primarily showing a configuration of a gate portion, and Fig. 1B is a layout diagram primarily showing a configuration of a light receiving portion including a vertical CCD portion (hereinafter, the same is also true of other drawings).

In Figs. 1A and 1B, the numeral number 1 designates a photodiode portion surrounded by a channel stopper portion 4, interpixel portions 5, and a gate portion 12, and the gate portion is adjacent to a vertical CCD portion 3.

In this embodiment, the CCD imaging apparatus is constructed so that a part of a gate 12B of the gate 12 which is not related to charge readout is cut in a slanted line form from a corner of the photodiode portion 1 to the vertical CCD portion 3, as opposed to the gate portion 2 of Figs. 4A and 4B, whereby the width L_{2-5} or W_4 of a gate portion 12a of a readout gate 12A adjacent to the photodiode portion 1 is widened up to the same width as that of the photodiode portion 1 and the width L_{2-4} or W_4' of a gate portion 12b of the readout gate 12A and the

gate length l_{1-4} at the vertical CCD portion 3 side is unchanged ($l_{1-4} = l_{1-1}$).

Light from a subject is photoelectrically converted in the photodiode portion 1 and thereby (signal) charges are generated. Applying a voltage to the gate portion 12 (the gate portion 12A goes on) causes the charges of the photodiode portion 1 to be read out to the vertical CCD portion 3 by the readout gate portions 12a and 12b.

The CCD imaging apparatus employs two types of gates, gate portions 12A and 12B. One of them is a gate used during charge readout, and the other is a gate not used for charge readout, placed below the former. In a portion where the two gate overlap, the gate not related to readout is dominant.

This embodiment is characterized in that a gate not related to charge readout is cut in a slanted line form as described above and the width L_{2-5} or W_4 of the readout gate portion 12a adjacent to the photodiode portion 1 is widened, so that an electric field applied to that portion is intensified during activation so that charges within the photodiode portion 1 can be easily read out.

Owing to the gate pattern, the gate width L_{2-4} or W_4' at the vertical CCD portion 3 side is the same as conventional ones. Therefore, a gate width adjacent to

the vertical CCD portion 3 can be maintained to an optimum width for the charge capacity and charge transfer efficiency of the vertical CCD portion 3 without influencing the charge capacity and charge transfers of the vertical CCD portion 3 and deteriorating other characteristics. Also, since a charge readout voltage is reduced by widening a gate width as described above, power consumption can be reduced. Yet, since the read gate length l_{1-4} is unchanged, the gate serves, during off operation, as an adequate barrier against charges so that there is no leak of charges from the photodiode portion 1 to the vertical CCD portion 3 and no leak of light to the vertical CCD portion 3.

The embodiment shown in Figs. 2A and 2B is characterized in that although the entrance gate width W_4 of the readout gate portion 12a and the exit gate width W_4' of the readout gate portion 12b are the same as those in Fig. 1, the gate width becomes gradually smaller from the photodiode portion 1 toward the vertical CCD portion 3.

The embodiment shown in Figs. 3A and 3B is characterized in that the gate width W_4 of the readout gate portion 12a becomes curvedly narrower from the photodiode portion 1 toward the vertical CCD portion 3.

It will be appreciated that any of these embodiments can bring about almost the same effect as in Figs. 1A and 1B.

Although the present invention preferably applies to the above CCD imaging apparatus, without being limited to it, the present invention is widely applicable to other photoelectric converters used for optical communications or other purposes if they are constructed with a light receiving portion, a gate portion, and a charge transfer portion. The patterns of the readout gate portion can be changed to various ones, and layouts including the shapes and sizes of the portions, and devices constituting the light receiving portion are not limited to the above ones.